A STUDY OF THE DIAGNOSTIC CHARACTERS OF TWO NORTH AMERICAN SPECIES OF THE GENUS *Diplocheila* BRULLE, WITH NOTES ON THEIR ECOLOGY (CARABIDAE, LICININI)

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The taxonomy of the North American species of *Diplocheila* has been recently reviewed by the second author, (Ball, 1959). Only small series of specimens of each species were available for that study and the amount of material from any one locality was, in general, very small, so that statements about geographical variation were based on composite samples of specimens from adjacent localities rather than samples from single localities. For example one of the largest groups of specimens of *Diplocheila striatopunctata* treated as a unit for purposes of analysis was from Ontario (Canada), and was composed of specimens from four different localities within this province. Of course, the most meaningful statements about variation are derived from series of samples consisting of large numbers of individuals, each group of which is collected in a single locality over a relatively short period of time.

Series large enough to permit further evaluation of the diagnostic characters and of the statements relating to geographical variation have now become available. Within the last four years, the second author has been able to accumulate material of two very similar and seemingly closely related species of *Diplocheila* which occur in south-central and western Canada, namely *striatopunctata* LeConte and *oregona* Hatch. It was decided to use these as the basis for a re-investigation of their supposedly diagnostic characters. This paper includes a summary and analysis of the data obtained, and information on the ecology and the feeding habits of the two species.

Measurements and spine counts were made by the first author, who also determined the statistical parameters, prepared the illustrations and the first draft of this paper. The second author directed the program, provided the ecological data and is responsible for the preparation of the manuscript.

Acknowledgments

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Zoology, University of Alberta, whom the second author accompanied to the Albertan prairies in 1955; EVELYN and STUART CRIDDLE, whose knowledge of the natural history of southern Manitoba and whose hospitality are unrivalled; J. B. WALLIS, who introduced the second author to the Manitoba insect fauna and to the Criddles in the summer of 1956; CARL H. LINDROTH, the Swedish biologist, whose knowledge of Canadian carabids both in the field and in the museum is without parallel; and GORDON STACE-SMITH, the foremost authority on the beetles of British Columbia, who took the second author to a number of excellent collecting localities in the vicinity of Creston.

MATERIALS AND METHODS.—This study is based on 279 specimens. The areas in which they were collected are indicated in Figure 1, and the localities are listed below. Two variates of taxonomic importance require explanation, namely total length of body and tibial spine counts. The total length of the body was taken as the sum of three measurements: The linear distance from the base of the clypeus to the posterior margin

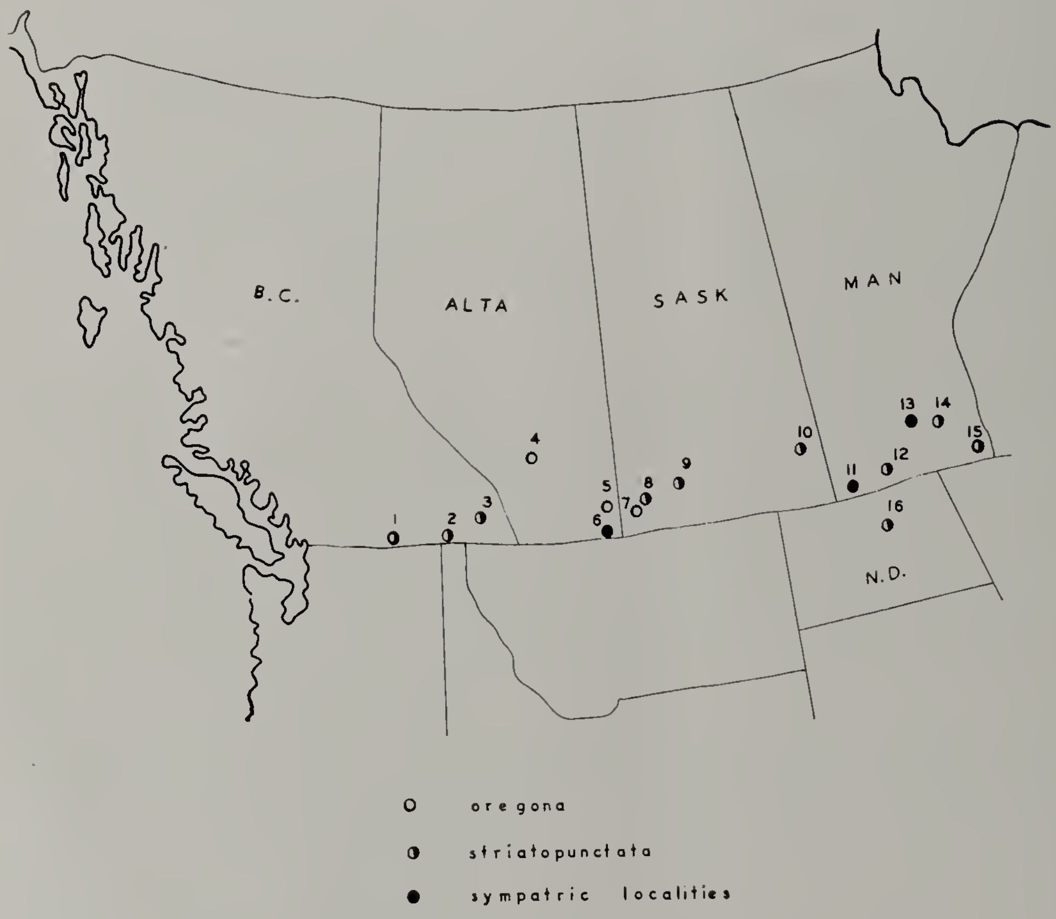


FIG. 1'

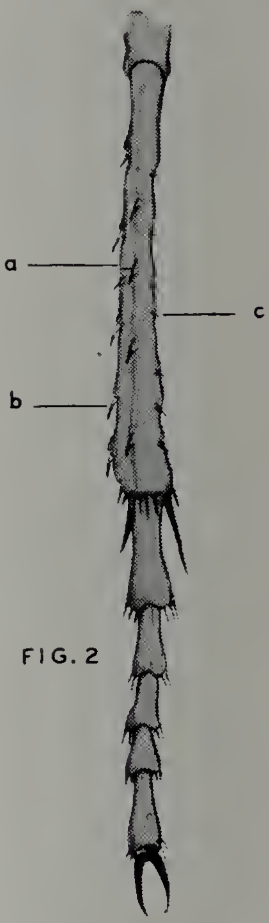


FIG. 2

FIGURE 1. Distribution of *D. striatopunctata* and *oregona*. 1. Osoyoos, Oliver. 2. Atbara. 3. Island Pond, Wasa Lake. 4. Keoma. 5. Ralston, Cypress Hills, Elkwater, Route 48. 6. Manyberries Range Station. 7. Cypress Hills Park, route 21. 8. Gull Lake. 9. Reed Lake. 10. Percival. 11. Whitewater Lake. 12. Glenboro, Baldur, Aweme. 13. Shoal Lake. 14. Selkirk, Little Stony Mountain. 15. White Houth Lake. 16. York.

FIGURE 2. Part of the hind leg of *D. striatopunctata*: a, posterior median row of spines; b, posterior external row; c, posterior internal row.

of the compound eye (taken on the left side); the linear distance from the apex to the base of the pronotum, along the mid-line; and the linear distance from the basal transverse groove of the left elytron to the elytral apex.

If the hind tibia is viewed from the posterior aspect, a longitudinally directed groove bearing a row of spines can be seen on each side. Between these rows on the median convex surface there is another row of spines, referred to here as the posterior median row (Figure 2, a). The number recorded for each specimen is the sum of the spines in the posterior median row of both hind tibiae.

Ball (1959) used the total body length and the presence or absence of a low dorsal tubercle on the left mandible to separate *striatopunctata* from *oregona*. The number of spines in the posterior median row of the hind tibiae was useful as a subsidiary character, and it appeared that this character would be useful at least in identifying population samples, even though it is somewhat too variable to determine individual specimens. The same was thought to be true of variation in color of elytra, the presence or absence of a puncture in the third elytral interval, and the relative convexity of the elytral intervals.

Using the mandibular character (tubercle present in *striatopunctata*, absent in *oregona*), the specimens were segregated into two groups. Each specimen was measured, scored for elytral color and presence or absence of a puncture in the third elytral interval, and the tibial spine counts were made. Statistical parameters were determined for total lengths and spine counts in those samples which consisted of 10 or more specimens. These are summarized in Figures 3 and 4 using Hubbs-Hubbs diagrams (1953). Graphs were prepared showing the relationship between spine count and total length for each specimen examined (Figures 5 and 6).

The median lobe of the male genitalia of five specimens of each species was studied. The basal bulb was found to vary considerably in shape, but no constant differences between the two species could be found.

Diplocheila striatopunctata LeConte, 1844

Specimens of this species numbering 106 males and 66 females, were collected in the following localities:

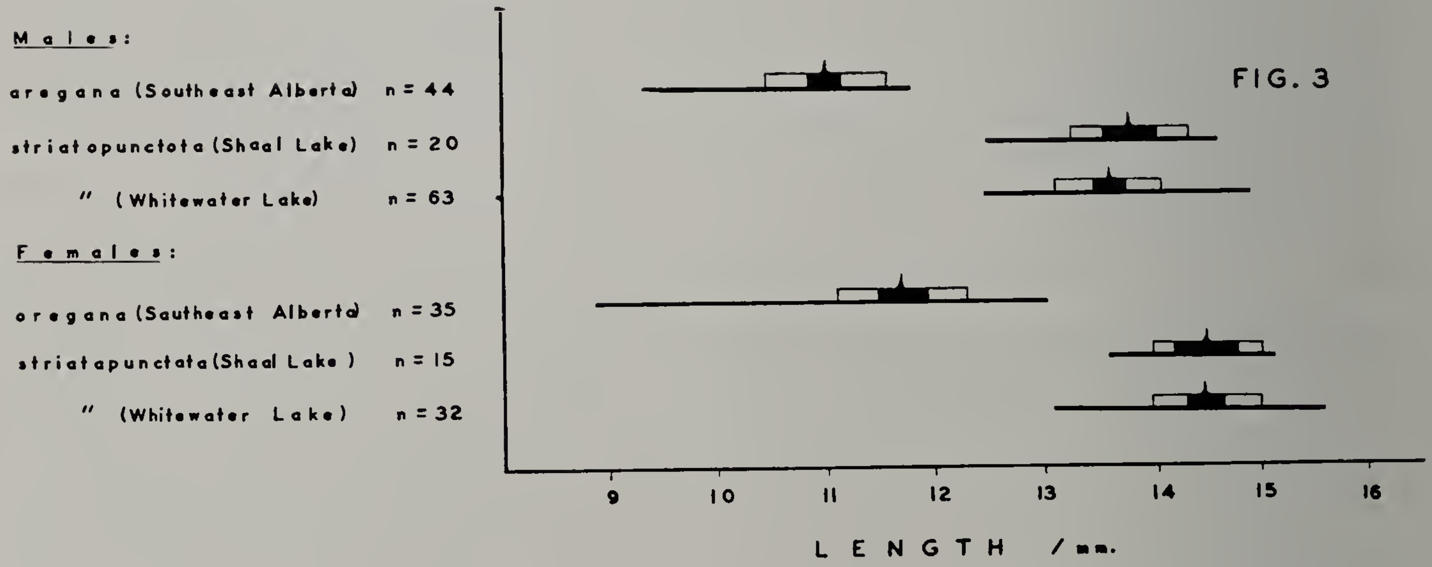
ALBERTA: Southeast Alberta 49° 04′ 20″ north, 110° 25′ 24″ west, [Manyberries Range Station]. (2 females).

BRITISH COLUMBIA: Atbara near Creston (6 males, 6 females); Island Pond 35 miles north Kimberly route 95 (one male); Wasa Lake, nr. Wasa (3 males, 3 females); Spotted Lake near Osoyoos (2 males); Okanagan River near Oliver (one female).

MANITOBA: Whitewater Lake (63 males, 32 females); Glenboro (2 females); Shoal Lake near Woodlands (20 males, 15 females); Little Stony Mountain near

Winnipeg (one male and one female); Whitemouth Lake (one male); Baldur (one female); Assiniboine River near Aweme (one male); Selkirk (one male).
NORTH DAKOTA: 11.9 miles west York (4 males, one female).
SASKATCHEWAN: One mile east Percival on route 1 (2 males, one female); 1.5 miles east Gull Lake (one female); Reed Lake near Morse (one male).

The series of specimens collected at Shoal Lake vary in total length as follows: males, 12.5-14.6 mm.; females 13.6-15.1 mm. The Whitewater Lake specimens exhibit these extremes: males, 11.3-14.9 mm.; females, 13.3-15.6 mm. The specimens collected from the remaining localities fall within these ranges, except for one female collected at Atbara (B.C.), which measures 13.0 mm. The specimens examined by Ball (1959) vary as follows: males, 12.5-15.9 mm.; females 14.1-17.9 mm. These values are higher than those reported in the present study. The mean values



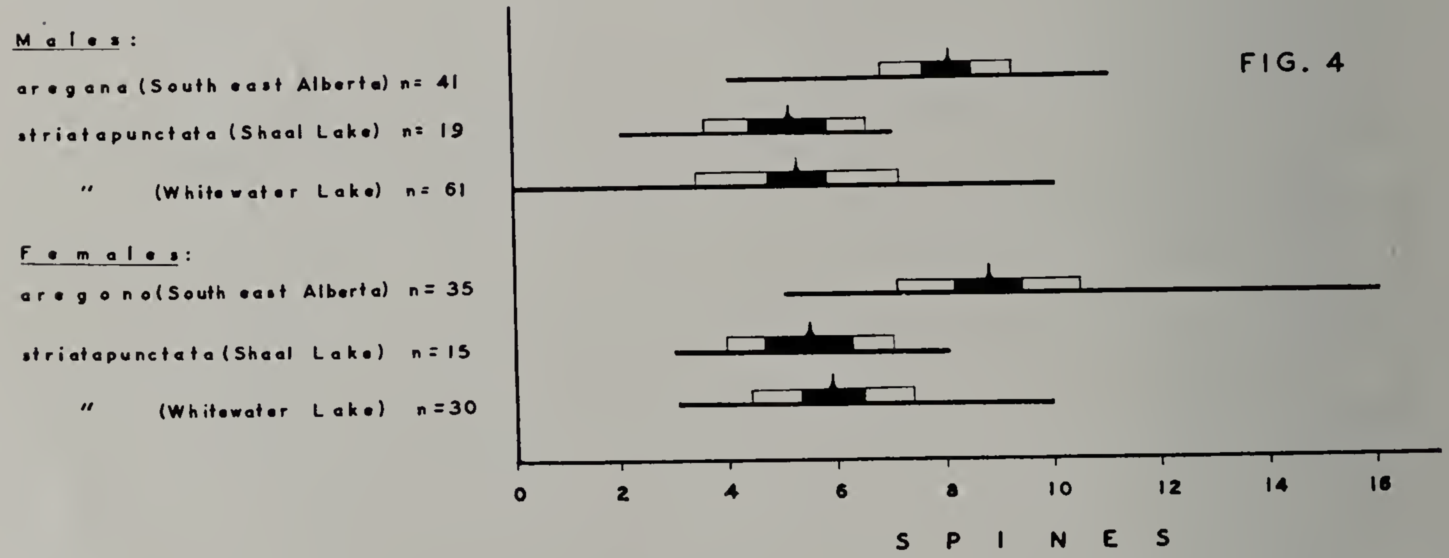


FIGURE 3. Body length of *D. striatopunctata* and *oregona*. Heavy horizontal line = the range of variation. Apex of the small narrow triangle = the mean. The blackened part of each bar = two standard errors of the mean on either side of the mean. One half of each black bar plus the white bar at either end = one standard deviation on either side of the mean.

FIGURE 4. Number of spines on the posterior median row of the hind tibiae in *D. striatopunctata* and *oregona*: The explanation of lines as in Figure 3.

given by Ball were based on composite samples, and therefore cannot be directly compared with the mean values given in the present study. They are higher than the values reported here but not significantly so.

Data on variation in the total number of spines in the posterior median row of the hind tibiae are presented in Figure 4. The maximum range of variation is seen in male specimens from Whitewater Lake, Manitoba, (0-10). This range exceeds by one unit that reported by Ball, 1959 (1-10 spines).

The elytra are bicolored in 66 per cent of the Shoal Lake, Manitoba specimens; and in 63 per cent of the Whitewater Lake, Manitoba specimens, with the even intervals reddish brown and the odd intervals black. Bicolored individuals were taken in all of the prairie localities listed below, except at Percival, Saskatchewan. In this locality only one specimen was found. The nineteen specimens collected in British Columbia are concolorous, black. According to Ball (1959) the percentage of bicolored individuals varies from 11 to 83 per cent, the highest values occurring in populations in the Great Plains area, decreasing both eastward and westward. The data reported here are not contrary to this statement.

In all specimens, at least some of the elytral intervals are noticeably convex (usually 6 and 7), and the elytral striae are deeply impressed, as compared with specimens of *oregona*. Interval 3 of at least one elytron per specimen bears a puncture in 77 per cent of the Whitewater Lake sample, in 75 per cent of the Shoal Lake sample, and in 75 per cent of the Atbara sample. The remaining specimens in each of these samples have all elytral intervals impunctate. The specimens from nine additional localities have impunctate elytral intervals. According to Ball (1959), the percentage of impunctate specimens varies from 100 to 58.3 per cent, depending upon the locality. Of the Manitoba-Saskatchewan sample, 72 per cent were reported as having punctate elytra, and the figures given above for the Manitoba samples are close to this value.

Diplocheila oregona Hatch, 1951

Specimens of this species numbering 56 males and 51 females, were collected in the following localities:

ALBERTA: Southeast Alberta 49° 04′ 20″ north, 110° 25′ 24″ west, [Manyberries Range Station]. (44 males, 35 females); Manyberries Range Station near One-Four (2 males); North Keoma route 9 (2 males, 4 females); North Ralston 50° 16′ north, 111° 34′ west (7 males, 4 females); Route 48, 49° 14′ 20″ north, 110° 15′ 00″ west (3 females); Elkwater (one female).

MANITOBA: Whitewater Lake (one male); Shoal Lake (one female).

SASKATCHEWAN: Cypress Hills Park (one female); 16 miles south Cypress Hills Park route 21 (2 females)

Specimens of this species collected in southeastern Alberta at the Manyberries Range Station, vary in length as follows: males, 9.3-11.8 mm.; females, 8.9-13.0 mm. (Figure 3). Specimens collected in the localities listed above fall within this range, except for two males from near Ralston, Alberta that were only 9.0 mm. The range of variation given by Ball for this species is: males, 10.5-12.6 mm.; females, 10.7-13.3 mm. Thus the values as reported by him are slightly higher than those given here.

The eyes are not as convex and therefore not as prominent as in *striatopunctata*, and the posterior angles of the pronotum are not sharply angulate. These differences are readily appreciated when series of these two species are available for comparison.

The number of spines in the posterior median row of the hind tibiae varies from 3 to 16 in the southeastern Alberta sample (Figure 4), and specimens from the other localities fall within this range of variation. Ball (1959) recorded a range of variation of 4 to 10 spines.

The elytra are concolorous in all the specimens examined. The striae are shallower and the intervals are less convex than in *striatopunctata*. Only three specimens have a puncture in interval 3 on a single elytron only. Ball (1959) did not report any specimens having punctate elytral intervals.

Field notes.—The specimens discussed above were collected along or near the margins of bodies of alkaline or fresh water, on clay or sandy soil. The Shoal Lake, Manitoba specimens were found under dried mats of algae, within ten feet of the water's edge. Although the mats were dry, the ground under them was saturated. Those taken at Whitewater Lake were collected on wet ground, within a few feet of the water, in a dense growth of prairie grasses. The specimens from Atbara, British Columbia were found in grassy vegetation at the margin of a small pond, within a short distance of the eastern margin of Kootenay Lake. They were driven out of their hiding places by treading on the soft, wet clay soil. The Wasa Lake specimens were found under boards on wet sand, within a few feet of the water. The single specimen collected along the Okanagan River at Oliver, B. C. was under a stone on moist, bare sand. Ball (1959) recorded a specimen taken in a similar area in northern Alberta. We believe the riparian habitat to be marginal for this species because specimens are found here infrequently. The large series of *oregona* taken at the Manyberries Range Station, in southeastern Alberta, was collected under stones at the edge of a temporary prairie pond. When this area was revisited during the following year, a rather dense growth of prairie grasses was found to occupy the depression which had previously been filled with water, and no specimens of *Diplocheila* could be found. These observations seem to indicate that the species dealt with are hygrophilous. That both species live in a similar if not identical habitat is indicated by the fact that they have been taken together in three different localities. However, they did not occur in equal abundance: out of 81 specimens of *Diplocheila* taken at Manyberries Range Station, 79 were *oregona,* and 2 only were *striatopunctata;* out of 93 specimens collected at Whitewater Lake, 92 were *striatopunctata* and one was *oregona;* and out of 36 specimens found at Shoal Lake, 35 were *striatopunctata* and one was *oregona.* Each of these samples was random in the sense that all specimens found were taken, and the same sort of area was sampled in each case, that is, close to the margin of a body of water. Possibly the dates of collection are of importance in evaluating the relative abundance, as the Manyberries sample was obtained early in May and the Manitoba collections were made in July.

As other licinine Carabidae are known to feed on snails, i.e. *Dicaelus* and *Licinus,* the second author decided to find out if *Diplocheila* also would eat molluscs. Captive specimens of *oregona* were offered small aquatic snails, obtained at a small pond near Edmonton. The reaction of each beetle was instantaneous. Each immediately attacked a snail, biting right through the shell with the mandibles. The soft parts were then consumed, and an empty, broken shell was left behind. It was not determined if this species would accept food other than snails. We presume that the other North American *Diplocheila* will feed on snails also, because they possess the same kind of mouthparts as *oregona,* and all are generally so similar that it would be very surprising if they did not have about the same habits.

Discussion.—Statistical analysis of the data shows that the body length and the number of spines on the hind tibiae are significant characters in separating the two species (Figures 3 and 4). The scatter diagrams (Figures 5 and 6) indicate that no linear relationship exists between these two characters, and so they may be regarded as the manifestations of independent sets of alleles. Further, it is apparent that the mandibular tubercle is a character of considerable diagnostic importance, for the statistically distinct populations were distinguished initially on the basis of the presence or absence of this protuberance.

Specimens typical of both of these forms (Figures 5 and 6) have been collected in the same habitat literally within inches of one another. This fact suggests that they are reproductively isolated, and so can be regarded as specifically distinct. Additional support for this contention is obtained from the variation in color of elytra and in the punctation of

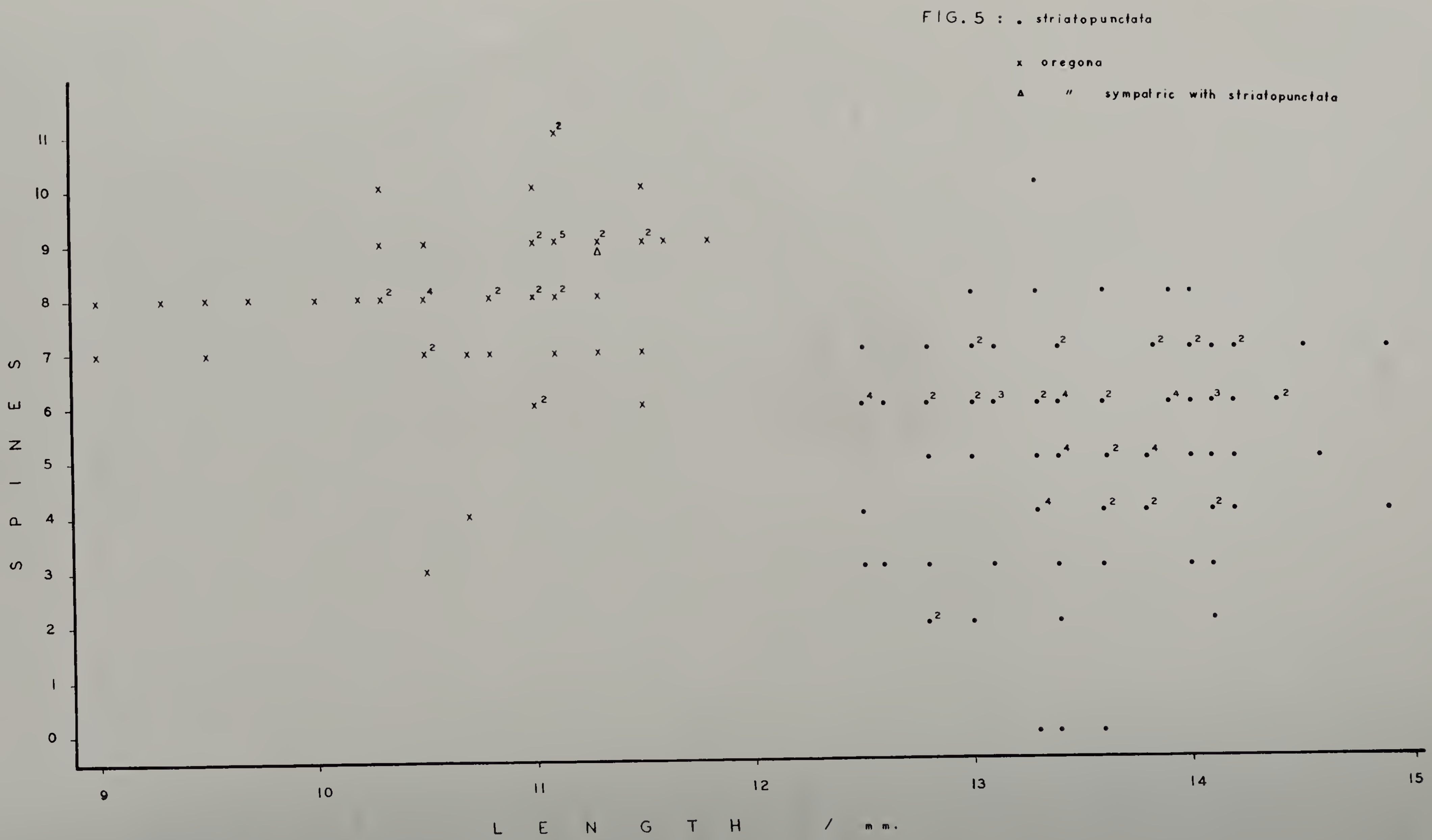


FIGURE 5. Scatter diagram showing the relationship between body length and the number of spines on the posterior median row of the hind tibiae in males of *D. striatopunctata* and *oregona*.

the third elytral interval as no specimen referable to the species *oregona* on the basis of the above characters has bicolored elytra, while substantial percentages of some samples of *striatopunctata* have bicolored elytra. The great majority of *oregona* lack a puncture in the third interval, whereas most of the specimens of *striatopunctata* have a puncture on each elytron.

The nature of the reproductive isolating mechanism, the postulation of which seems to be required by the morphological facts, is not known at present. Although the species are sympatric in the prairie provinces at least, it is possible that they are largely allochronic, so that when the adults of *striatopunctata* are abundant the adults of *oregona* are scarce and *vice versa* (see above). If this were the case, the possibility of interbreeding would be slight. On the other hand, the frequency of encounters between individuals of the two species may be restricted by microecological differences which can be appreciated only by careful experimental studies, not by casual field observations.

As mentioned above and in Ball (1959), *striatopunctata* exhibits dimorphism in elytral color, and the frequency of the two color types varies geographically. The pattern seems to be a central-peripheral one, with the bicolored condition predominating at the geographical center of the species range, and the opposite condition predominating at the eastern and western periphery. Brown (1958) gives a discussion of this type of pattern. Neither the cause nor the significance of this dimorphism in *striatopunctata* is understood at present.

These data substantiate the conclusions arrived at by Ball (1959) concerning the taxonomic status of *striatopunctata* and *oregona*.

SUMMARY

1. Data are presented on variation in morphological characters and in geographical distribution of several population samples collected in south-central Canada and north-central United States which show that *Diplocheila striatopunctata* LeC. and *D. oregona* Hatch are specifically distinct.
2. It is suggested that color dimorphism in the elytra of *striatopunctata* exhibits a so-called "central-peripheral" pattern of geographical variation.
3. Ecological observations show that *striatopunctata* and *oregona* are pronouncedly hygrophilous, living under cover near the margins of bodies of water.
4. It is noted that *oregona* eats aquatic snails, and gets at the meat by breaking the mollusc shell with its mandibles. It is not known if this species takes other food.

LITERATURE CITED

BALL, G. E. 1959. A taxonomic study of the North American Licinini with notes on the Old World species of *Diplocheila* Brullé. Memoir 16, *American Entomological Society*. i-iv + 258 pp. Figs. 1-165.

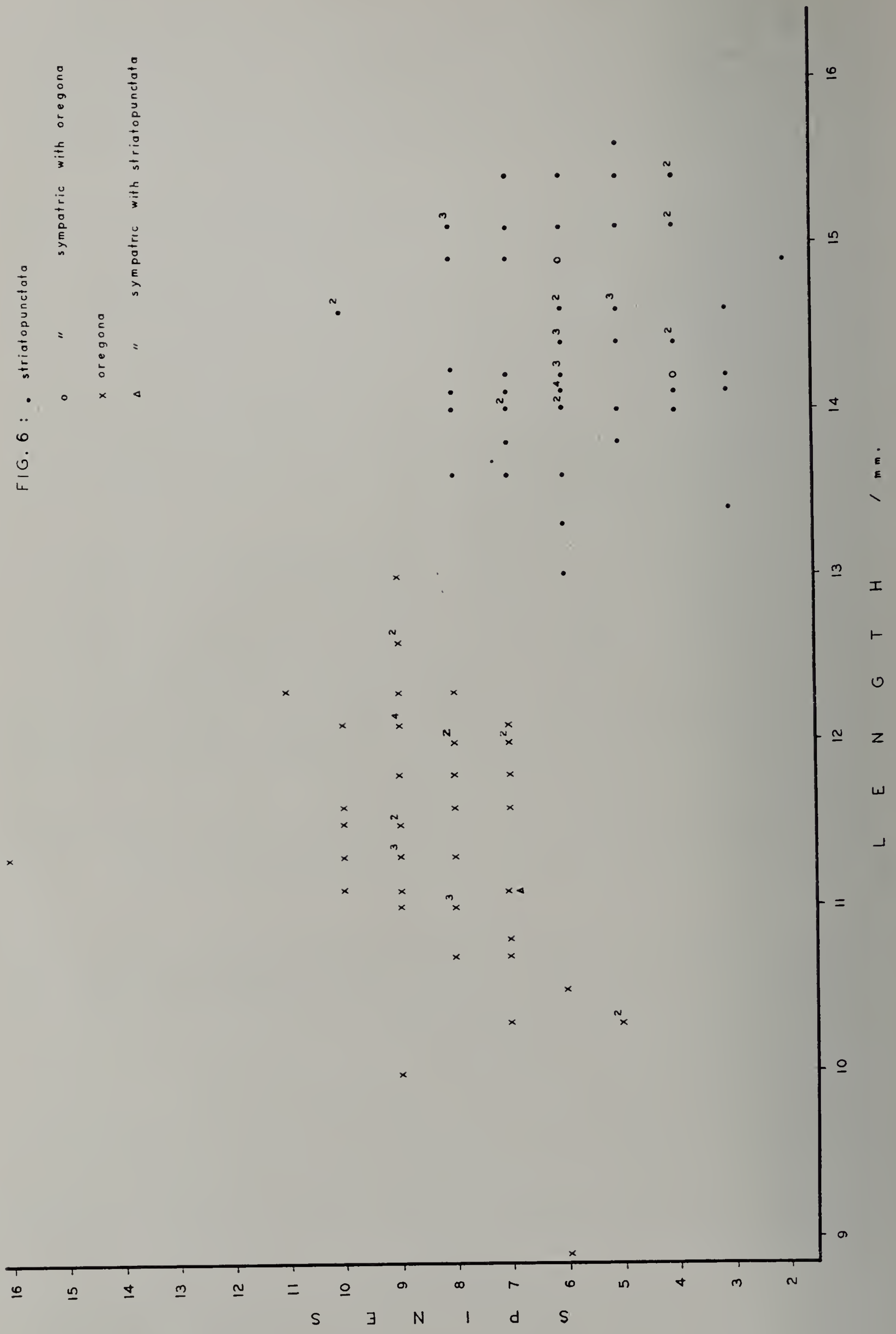


FIGURE 6. The same as Figure 5 for females.

Brown, W. L. 1958. Speciation: the center and the periphery. *Proceedings of the Tenth International Congress of Entomology.* 1: pp. 89-99.

Hubbs, C. L. and C. Hubbs. 1953. An improved graphical analysis. *Systematic Zoology* 2: pp. 49-56.

REVIEW

Coccinellidae of Poland

(Klucze do oznaczania owadów Polski. Czesc XIX. Chrzaszse *Coleoptera.* Zeszyt 76. Biedronki. Coccinellidae.) By Ryszard Bielawski. Warszawa 1959. Panstwowe Wydawnictwo Naukowe). 92 pages. 42 unnumbered plates, 266 numbered illustrations.

This is the 11th out of 100 proposed volumes covering beetles of the present territory of Poland. The order of appearance of these volumes has nothing to do with the taxonomic sequence, and publications appear as there are available taxonomists, willing to work on their particular specialties.

Bielawski in this volume covers not only forms actually taken on the present Polish territory (23 genera and 69 species) but also a number of species found in adjacent areas which may occur in Poland, thus bringing the total under the discussion to 38 genera and 80 species. Most numerous of these is *Scymnus* here represented by 19 and 16 species respectively.

The author synonymizes several species and contrary to the common European practice almost completely ignores the nomenclature of the color varieties for each species.

The work follows pretty much established tradition of the detailed studies carried out on the beetles in Central Europe of which Polish publications represent one of the best examples. A multitude of illustrations of numerous characters enable to identify species even to those unfamiliar with the language. (The text is entirely in Polish without any foreign summaries).

There are good accounts of general biology and ecology of the Coccinellids and for each species there are given biological, distributional and ecological data in great detail. One may wish that this last practice would be followed in our own country. Unfortunately our coleopterists tend to ignore such data all too often, even when the information is present on the labels or can be readily provided by the collectors.

On the other hand, the author seems not too familiar with the North American literature if one may judge from some of the comments he makes concerning the use of Coccinellids in the biological control in U. S. and from his ignoring the establishment of *Coccinella undecimpunctata* in the eastern part of this continent. Just the same, it is the sort of work the example of which we may well follow.—Borys Malkin, *University of Minnesota, Minneapolis, Minn.*